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EVALUATION OF LATE FAILURES AFTER RECONSTRUCTIVE OPERATIONS FOR OCCLUSIVE LESIONS OF THE AORTA AND ILIAC, FEMORAL, AND POPLITEAL ARTERIES

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EXTENSIVE laboratory and clinical investigation during the past 10 years has led to recognition of the frequent segmental nature of atherosclerotic occlusive lesions in patients with chronic arterial insufficiency of the lower extremities and development of techniques to attack these lesions directly. Several procedures [1-3, 5-7] utilizing a variety of arterial replacements in the treatment of this disease have evolved since the early work of dos Santos[4] with endarterectomy. The high percentage of good initial results obtained by continued improvement in technique and increasing surgical experience has led to treatment of many patients with occlusive lesions of the aorta and iliac, femoral, and popliteal arteries by reconstructive operations during the past 6 years.[2, 3, 5, 6] Although pulsatile blood flow in the arterial bed distal to the occlusion has been restored and symptoms of arterial insufficiency have been relieved in most patients, long-term postoperative observation has revealed a significant number of recurrent difficulties.[1, 5, 6] Our experience with this problem in the treatment of 1,225 patients with occlusive lesions of the distal aorta, and iliac, femoral, and popliteal arteries during the last 6 years was reviewed in an attempt to evaluate this form of therapy to discover possible causative technical surgical factors, and to evaluate the therapeutic measures employed for recurrent occlusion.

CLINICAL MATERIAL

The lesions were located in the distal aorta and iliac arteries in 638 of the 1,225 patients and in the femoral and popliteal arteries in 587. The indications for operation were rest pain or intermittent claudication (which was frequently disabling) in 80 per cent of the patients and in the remaining 20 per cent cutaneous lesions that posed an immediate threat to life. Patients were selected for operation on the basis of operative risk and demonstration of localized disease. The technique and immediate results of operation employed in these cases varied with the location and extent of the disease and the quality of the arterial replacement available at the time of treatment as indicated in the following discussion.

Aortoiliac Occlusion.—Lesions of the aortoiliac region were treated by thromboendarterectomy, excision and graft replacement, excision and graft replacement combined with bypass, or bypass graft alone (Table I). Almost all of the earlier patients in the

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series were treated by excision and graft replacement. Later, selection of the procedure to be employed depended upon the nature and extent of the occlusive process. Thus, a well-localized process associated with minimal medial mural involvement was treated by thromboendarterectomy. Localized lesions with more extensive medial and adventitial involvement were excised and continuity was restored by graft replacement. Localized lesions with extensive distal involvement were treated by excision with graft replacement and bypass. Under these circumstances the iliac segments of the aortic bifurcation graft were brought down and anastomosed end-to-side to a patent segment of the distal arterial bed, such as the external iliac, femoral, or even the popliteal artery. The bypass procedure without resection or endarterectomy was employed for extensive occlusive lesions involving the distal aorta extending well into the external iliac arteries. In most of these cases aortofemoral bypass was performed, but in some, because of associated segmental occlusion in the superficial femoral artery, it was necessary to extend the bypass to the popliteal artery. An important consideration in these latter cases is the fact that the profunda femoris, along with a small segment of the common femoral artery opposite its opening, is usually patent. In order to improve circulation in the tissues supplied by the profunda femoris and to provide additional runoff for the aortic graft, side-to-side anastomosis was performed between the graft and the patent segment of the common femoral artery immediately opposite the opening of the profunda femoris as well as between the graft and the popliteal artery.

TABLE I. RESULTS IN 638 CASES OF AORTOILIAC OCCLUSION ACCORDING TO TYPE OF OPERATION

		IMMEDIATE SUCCESS		LATE FAILURE				
						REOPERATION		
							SUCCESSFUL	
PROCEDURE	CASES	CASES	PER CENT	CASES	PER CENT	CASES	CASES	PER CENT
Excision and graft replacement	148	141	95	19	13.0	19	17	90
Endarterectomy	121	116	96	3	2.4	3	3	100
Excision and graft replacement with bypass	161	153	95	8	5.2	8	7	87
Bypass only	208	201	97	8	3.8	6	5	83
Total	638	611	96	38	6.2	36	32	91

The types of grafts employed in this group of patients are shown in Table II. Freeze-dried aortic homografts were used predominantly in our early experience. The various synthetic tubes, principally the Edwards-Tapp braided nylon tube, were used from about June, 1956, to the early part of 1957, with satisfactory results. However, all had certain disadvantages resulting from their availability or construction and physical characteristics which limited their adaptability to specific problems and increased the difficulties in their technical application. To overcome these obstacles a flexible, knitted, Dacron tube was developed and this has been used almost exclusively since January, 1957.

TABLE II. RESULTS OF TREATMENT OF AORTOILIAC OCCLUSIONS ACCORDING TO TYPE OF GRAFT REPLACEMENT

		IMMEDIATELY SUCCESSFUL		LATE FAILURE				
						REOPERATION		
							SUCCESSFUL	
TYPE	CASES	CASES	PER CENT	CASES	PER CENT	CASES	CASES	PER CENT
Homograft	173	160	92	20	12.0	20	17	85
Other substitute	69	66	96	10	15.0	8	8	100
Dacron	275	269	98	5	1.8	5	5	100
Total	517	495	96	35	6.8	33	30	91

The results of operative correction of aortoiliac occlusion were classified as successful only if pulses were restored. Failures included patients who died and those in whom distal arterial pulsations could not be demonstrated or who subsequently required amputation even though some improvement may have occurred after operation. On the basis of these criteria reconstructive operation was successful in 96 per cent of the cases (Tables I and II). The results of operation varied somewhat with the type of graft employed, ranging from 92 per cent immediate success with homografts to 98 per cent with the newer Dacron tubes (Table II). There were 16 operative deaths (2.5 per cent) in the entire series. Coronary thrombosis caused death in 9 patients, renal failure and uremia in 4, secondary hemorrhage in 2, and pulmonary embolism in one. In the remaining patients early failure was due to extensive occlusive disease in the peripheral arterial bed precluding direct surgical attack in this region. Amputation of an extremity became necessary in 7 of these, all of whom had severe ischemic changes associated with gangrene before operation. Particularly noteworthy is the fact that circulation in the opposite extremity was improved in all of these patients.

Femoropopliteal Occlusion.—In an attempt to restore immediate distal pulsatile circulation in patients with occlusive lesions of the femoral and popliteal arteries, thromboendarterectomy, excision and graft replacement, or end-to-side bypass graft was employed (Table III). During our early experience these lesions were usually treated by endarterectomy or excision and graft replacement. These procedures were soon almost completely abandoned in favor of bypass grafting since they were associated with relatively high morbidity and failure rates, presumably because of the extensive nature of the procedures, the destruction of collateral channels, and the frequent incomplete removal of the occlusive disease. More recently, endarterectomy has been performed only if the disease is well localized to a short segment of artery. Excision is no longer done. The occlusive process usually involved long segments of the femoropopliteal artery. End-to-side bypass graft was thus considered the procedure of choice in 91 per cent of the cases. In most cases the bypass graft extended proximally from the common femoral artery which was rarely involved by the occlusive process to the patent popliteal artery distal to the occlusion. The operation was performed through two small separate incisions which were connected by a tunnel made by blunt dissection. Among the substances used for vascular replacement were reconstituted freeze-dried arterial homografts, tubes made of compressed Ivalon sponge, braided nylon tubes (Edwards-Tapp), and flexible knitted Dacron tubes (Table IV). These substances were employed during the same periods for reasons previously described in the treatment of aortoiliac occlusion. The Dacron tube was the most satisfactory and was used in 356 patients or 61 per cent of the entire series.

TABLE III. RESULTS OF TREATMENT OF FEMOROPOPLITEAL OCCLUSION ACCORDING TO TYPE OF OPERATION

PROCEDURE	CASES	IMMEDIATE SUCCESS		LATE FAILURE				
						REOPERATION		
							SUCCESSFUL	
		CASES	PER CENT	CASES	PER CENT	CASES	CASES	PER CENT
Endarterectomy	29	20	69	3	15	1	1	100
Excision and graft replacement	19	16	84	14	87	3	3	100
Bypass	539	479	89	92	20	60	54	90
Total	587	515	88	109	21	64	58	91

Distal pulsatile circulation was maintained until after discharge from the hospital in 515 (88 per cent) of the 587 patients with lesions at this level (Table III). The incidence and successful results varied somewhat with the type of procedure and vascular replacement employed. For example, only 20 of the 29 patients (69 per cent) treated by

TABLE IV. RESULTS OF TREATMENT OF FEMOROPOPLITEAL OCCLUSION ACCORDING TO TYPE OF VASCULAR REPLACEMENT

REPLACEMENT	CASES	IMMEDIATE SUCCESS		FOLLOW-UP MONTHS	LATE FAILURE		REOPERATION		
								SUCCESSFUL	
		CASES	PER CENT		CASES	PER CENT	CASES	CASES	PER CENT
Homograft	83	71	85	24-66	37	52	13	12	92
Braided nylon	113	98	86	20-37	32	32	20	19	95
Ivalon	6	0	0	0	0	0	0	0	0
Knitted Dacron	356	326	91	0-25	37	11	30	26	86
Total	558	495	89	0-66	106	21	63	57	91

endarterectomy, and 16 of the 19 patients (84 per cent) who had excision and graft replacement had successful restoration of circulation. Circulation was restored in 479 of the 539 patients (89 per cent) treated by end-to-side bypass. Operation was unsuccessful in all 6 patients in whom an Ivalon tube was used in the bypass graft. Circulation was restored in 85 per cent of patients in whom homografts were employed and 86 per cent of those in whom the Edwards-Tapp tube was inserted. The best results were obtained with the Dacron bypass graft; restoration of circulation was successful in 326 of the 356 patients (91 per cent) in whom this material was employed. Major amputation was required in 11 of the failures (2 per cent) and 3 patients died.

Failure was due to the extensive nature of the disease in most instances; however, the extent to which this led to early failure was related to the type of procedure employed. For example, failure occurred in operable cases (by current standards) in the earlier cases of endarterectomy and excision and graft replacement. During this period, operation frequently consisted of resection or endarterectomy limited to the region of major occlusion without regard for obstructing lesions proximal and distal to the operative site. These partial occlusions were frequently significant, causing retardation of blood flow in the region of operation, early thrombosis, and failure (Fig. 1). In more recent cases in which operation failed, the disease was diffuse, being associated with partially obstructed distal segments and secondary occlusion in the lower leg beyond the present scope of operation.

METHOD OF STUDY

Most of the patients in this series have been followed since discharge from the hospital by personal examination and the others by correspondence with the patient, his family, or his physician. Difficulty relating to the circulation of the lower extremities recurred from one week to 66 months after discharge from the hospital in 38 of the 611 patients (6.2 per cent) with aortoiliac occlusion and 109 of the 515 (21 per cent) with femoropopliteal occlusion in whom operation had been initially successful. Of these 147 late failures, 121 were studied, 38 with aortoiliac and 83 with femoropopliteal recurrent difficulty. Angiograms made before the original operation and patients' charts, including diagrammatic sketches of the operative technique employed, were available in all cases. Angiograms made after failure were available in 105 cases and similar studies performed serially before operation and before and after late failure were available for analysis in 35 cases. Finally, the operative findings in 100 cases submitted to reoperation for late failure were also analyzed and correlated with the other studies.

RESULTS OF STUDY

The incidence, etiology, and rate of late failures varied with the location of the original lesion, the period during which operation was performed, the procedure employed, and the type of material used for graft replacement. The incidence of recurrent difficulty was more than three times greater in patients

with femoropopliteal lesions than in those with occlusion of the aortoiliac segment. This extreme difference justifies division of the problem again into these two groups for purposes of discussion.

Aortoiliac Lesions.—The late failures in the 38 patients in whom reconstructive operations had been successful initially for atherosclerotic occlusive disease of the aortoiliac segment were due to a variety of late complications (Tables V and VI). Failure was due to development of false aneurysm at the site of distal anastomosis in 3 (7 per cent), erosion between the graft site and duodenum in 6 (16 per cent), aneurysmal deterioration of the graft in 2 (5 per cent), and recurrent obstruction in 27 cases (71 per cent) (Figs. 2 and 3). The latter complication was due to kinking of the graft in 3 (7 per cent), presence of distal disease preoperatively in 10 (26 per cent), and progressive narrowing and

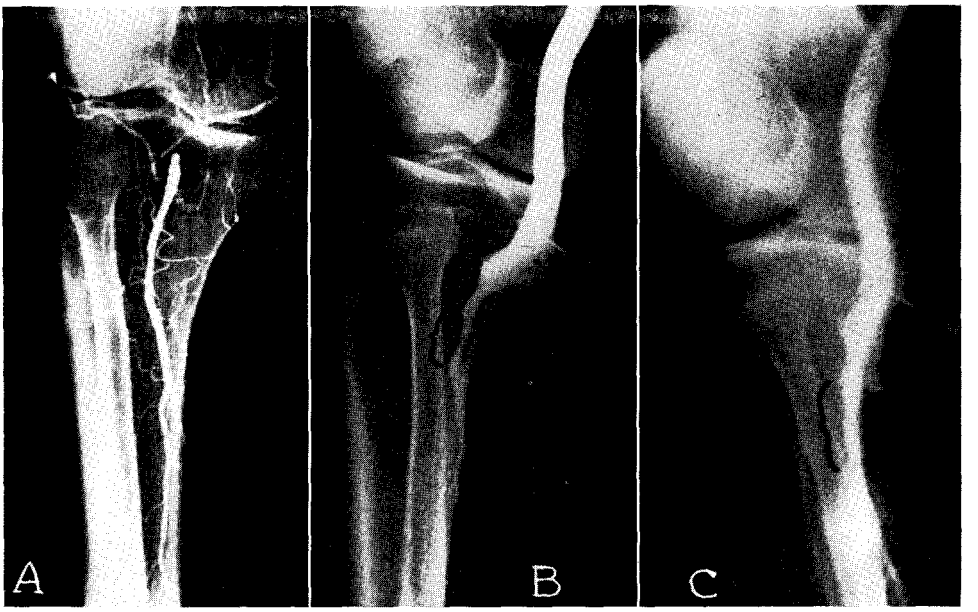


Fig. 1.—Photographs illustrating immediate operative failure because of distal occlusive disease. *A*, Preoperative arteriogram showing distal occlusive disease (*in brackets*). *B*, Arteriogram made immediately after removal of thrombus from graft again showing distal occlusion which caused obstruction and thrombosis. *C*, Arteriogram made after endarterectomy and patch graft closure of arterial incision permitting good outflow and eventual success of operation.

eventual thrombosis in 5 (13 per cent) in whom anastomotic narrowing had been present from the time of the original operation (Fig. 3). The cause of recurrent obstruction in the remaining 9 patients (24 per cent) was not entirely clear; however, correlation of the observations at reoperation with the aortograms made before the original operation and after failure suggested that obstruction was due to distal disease in the external iliac arteries overlooked at the time of operation. The interval between operation and late failure ranged from 1 to 52 months (Table V). Although this interval did not vary significantly with the complication causing failure, the longest period of temporary function was in the patients in whom recurrent obstruction developed from progression of untreated

disease. The first 2 years after operation were the most critical from the standpoint of recurrent difficulty, 69 per cent of the complications developed during this time. The incidence of recurrences after 2 years was indeed small.

The incidence of failure varied with the type of procedure performed and the material employed as the vascular replacement. For example, late failure

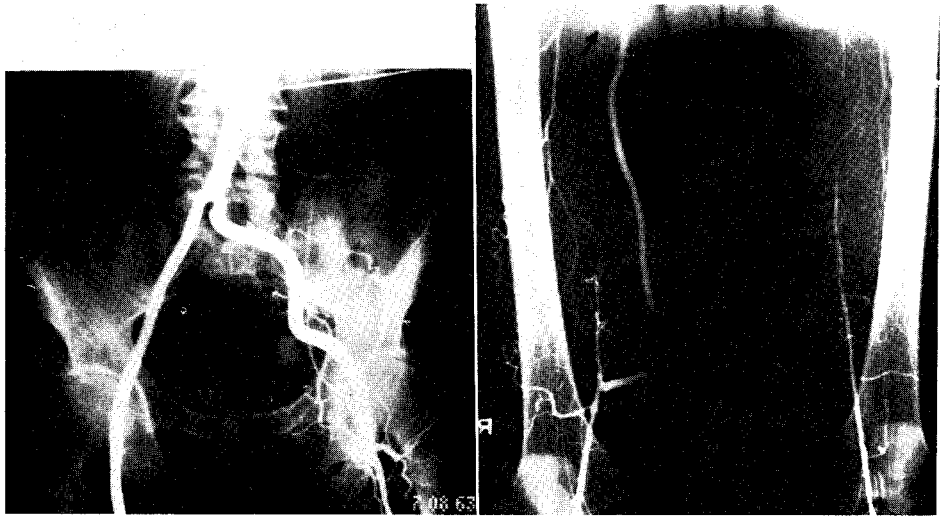


Fig. 2.—Aortogram and femoral arteriograms made 21 months after aortic excision and replacement with bypass graft of braided nylon, showing false aneurysms (*arrows*) at suture line between graft and common femoral arteries.

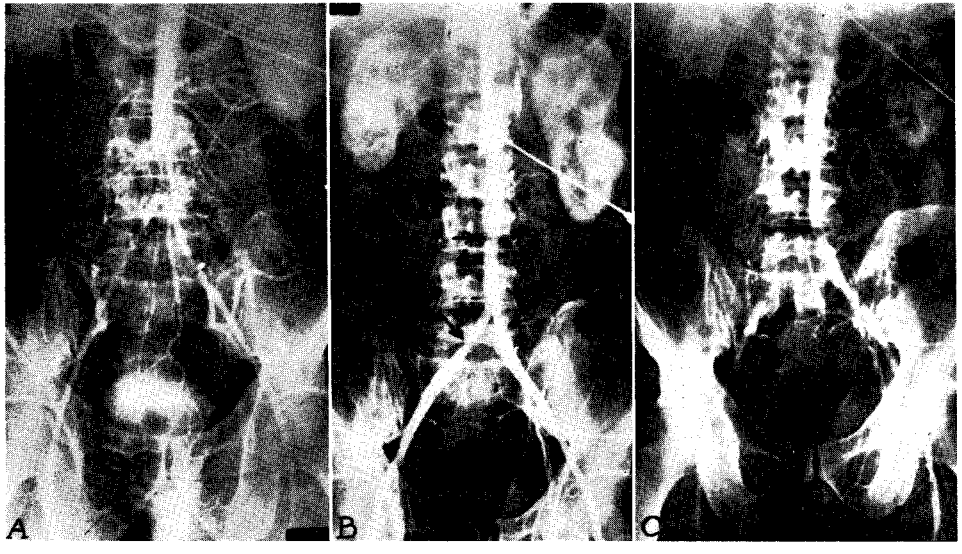


Fig. 3.—Photographs illustrating progressive narrowing at anastomotic site after excision and replacement with homograft. *A*, Preoperative aortogram showing complete occlusion of distal aorta. *B*, Aortogram 30 months after operation showing stenosis (*arrows*) in region of anastomosis. *C*, Aortogram 54 months after operation showing progression of obstruction, complete on right and incomplete on left.

TABLE V. CAUSES OF LATE FAILURE AND REOPERATION IN 38 PATIENTS WITH AORTOILIAC OCCLUSIONS

CAUSES OF FAILURE	CASES	PER CENT	MONTHS POST-OPERATIVE	LESION REMAINED SEGMENTAL	REOPERATION		
					CASES	SUCCESSFUL CASES	SUCCESSFUL PER CENT
Aortoduodenal fistula	6	16	2-30	6	5	4	80
Aneurysm of graft	2	5	18-24	2	2	1	50
False aneurysm	3	7	1-22	3	3	3	100
Kinked graft	3	7	5-23	3	3	3	100
Distal disease	10	27	3-38	10	10	10	100
Narrowed anastomosis	5	13	3-52	5	5	5	100
Recurrent obstruction (cause unknown)	9	24	2-46	9	8	7	88
Total	38	100	1-56	38	36	33	91

after excision and graft replacement occurred over three times more frequently than after endarterectomy or operations employing the bypass principle (Table I). Late failure was rare in patients in whom the flexible, knitted, Dacron tube was used: only 1.8 per cent of the cases (Table II) as contrasted with 12 per cent in patients with homografts and 15 per cent in those who had synthetic materials other than the Dacron tube. These differences in failure rate were also related significantly to the time in the series when the operation was performed as well as to the physical characteristics of the vascular replacement. Both excision and replacement with a homograft were employed almost routinely in the earlier cases, frequently without regard to partial involvement of the more distal iliac arteries. During this period a precise method of end-to-end anastomosis was being evolved, and the need to surround the graft by viable tissues to incorporate the graft, and particularly to separate it from the duodenum, had not been recognized. This combination of factors led to a higher incidence of failure resulting from aortoduodenal fistula, narrowed anastomosis, and recurrent obstruction (Table VI). Aneurysmal deterioration occurred in the femoral segments of two aortoiliofemoral homografts employed early as aortofemoral bypass grafts, again reflecting the limitations inherent in the use of homografts (Fig. 4).

Techniques of operation had been extended and improved to incorporate the bypass principle by the time braided nylon tubes were adopted as the vascular replacement. With increasing surgical experience and better concepts of the

TABLE VI. CAUSES OF LATE FAILURE ACCORDING TO REPLACEMENT IN 38 CASES OF AORTOILIAC OCCLUSION

REPLACEMENT	AORTO-DUODENAL FISTULA	ANEU-RYSM OF GRAFT	FALSE ANEU-RYSM	RECURRENT OBSTRUCTION				TOTAL
				NAR-ROWED ANASTO-MOSIS	KINKED GRAFT	DISTAL DISEASE	CAUSE NOT PROVED	
Homograft	4	2	0	5	0	5	4	20
Dacron	1	0	0	0	1	2	1	5
Braided nylon (Edwards-Tapp)	1	0	3	0	2	0	4	10
No replacement (endarterectomy)	0	0	0	0	0	3	0	3
Total	6	2	3	5	3	10	9	38

pathologic process, the late failure rate from distal disease was significantly reduced. However, certain physical characteristics of the vascular replacement resulting from its method of construction introduced other factors that led to a relatively high incidence of late failure. Flexibility was sacrificed and fraying of the cut ends of the graft prevented precise anastomosis. These limitations, inherent in this type of replacement, resulted in development of false aneurysm and obstruction from kinking of the graft (Table VI). Introduction of the crimped knitted Dacron tube increased flexibility and eliminated fraying and its associated production of false aneurysm. Application of the Dacron tube in most of the recent cases as a bypass graft extending from the aorta to the common femoral arteries decreased the possibilities of overlooking distal iliac disease which would later lead to recurrent obstruction. Consideration of these factors resulted in a higher incidence of long-term function with use of the Dacron tube than with the other replacements.

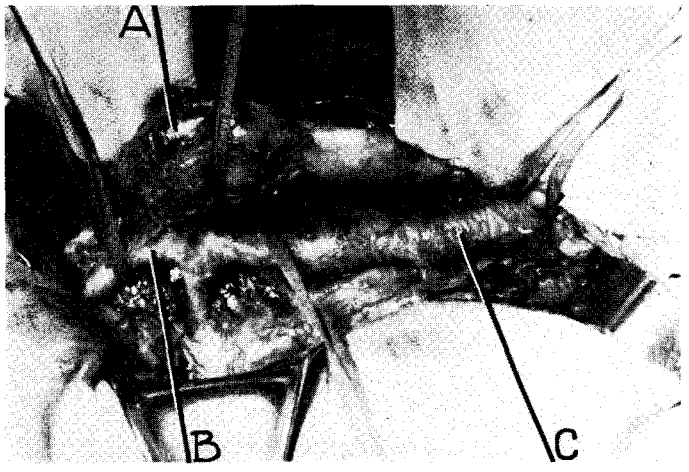


Fig. 4.—Photograph at second operation demonstrating aneurysm of femoral segment of aortoiliofemoral homograft (*A*) employed as aortofemoral bypass, occurring 36 months after first operation. *B*, Superficial femoral artery. *C*, Common femoral artery.

The recurrent lesion in all cases in this series was segmental and 36 patients were reoperated upon. The indications for reoperation were aortoduodenal fistula in 5, false aneurysm in 3, aneurysm of the graft in 2, and recurrent obstruction in 26 cases. One patient with recurrent obstruction declined operation and one patient with aortoduodenal fistula died before operation could be performed. The operative procedure employed in these cases varied with the lesion. The false aneurysms and the aneurysms involving the femoral segments of aortofemoral bypass grafts were located in the inguinal region. These lesions were excised and replaced with braided nylon tubes sutured proximally to the end of the previous graft and distally to the femoral artery at the site of the previous anastomosis. All patients with recurrent obstruction were treated by the bypass principle. The proximal end of the tube was sutured to the side of the aorta above the obstruction and previous site of operation in 25 cases. In the remaining case the partially obstructed homograft was excised and replaced

by a Dacron tube. The distal ends of the tubes in all cases were brought down and attached by end-to-side anastomosis to a patent segment of the distal arterial bed. In 20 cases it was possible to apply the procedure as an aortofemoral bypass. In 6 cases, however, it was necessary to extend the bypass to the popliteal artery because of secondary disease of the superficial femoral artery. In the latter cases side-to-side anastomosis was made between the patent common femoral artery and graft for reasons previously described.

Treatment of aortoduodenal fistula presented special problems concerning primarily the diagnosis, control of hemorrhage during operation, and management of an infected graft site. The diagnosis was suggested by the history of an aortic graft operation and by the symptoms. The predominant symptom was intermittent upper gastrointestinal hemorrhage. The bleeding episodes were mild to severe, occurring over a period of hours to 4 days. An extremely important characteristic of the bleeding was the fact that these patients did not have symptoms of other lesions commonly associated with gastrointestinal hemorrhage, namely, peptic ulcer, esophageal varices, and hiatal hernia. Immediate exsanguination fortunately did not occur in 5 patients, so that the operation necessary for both diagnosis and treatment could be performed. Because of the intimate adherence of the duodenum to the graft site, the diagnosis was not obvious from simple exploration of the abdominal cavity. The fistula and site of bleeding could be demonstrated only by separating the duodenum from the aortic graft. To control hemorrhage during operation circulation through the abdominal aorta was temporarily arrested by placing a clamp across the upper abdominal aorta in the hiatus of the diaphragm. A segment of aorta was then exposed between the renal arteries and the graft site. A clamp was placed across the aorta at this level and the other clamp was removed. With circulation maintained to the abdominal viscera and arrested in the region of operation, the previously inserted grafts were removed. In 3 patients aortoduodenal fistula occurred 12 to 26 months after insertion of a homograft to replace the distal abdominal aorta as a result of erosion by false aneurysm. False aneurysm was due to degeneration of the graft in the region of an unabsorbed unorganized collection of fluid between the duodenum and graft. Infection was not present in these cases; consequently, the duodenal defect was closed by simple suture and aortic continuity was restored by insertion of a new graft. Infection and abscess had caused erosion into the duodenum and the suture line in 2 patients in whom synthetic tubes (Dacron in one and braided nylon in the other) had been inserted as aortofemoral bypasses. Aortic continuity was not restored in these cases because of fear of recurrent infection and secondary hemorrhage. The aorta was ligated by suture above and below the region of anastomosis and the femoral arterial defects were closed by simple suture. Recurrence of fistula was prevented by suturing the omentum between the duodenum and aorta.

The results of reoperation were extremely satisfactory (Tables I, II, and V). Normal peripheral circulation was restored in 33 of the 36 cases (91 per cent). A distal pulsatile circulation was not restored in the 2 patients in whom aortic continuity was not restored after removal of infected synthetic tubes. One of the iliac arteries was incompletely obstructed before operation in one of these

patients and collateral circulation was insufficiently developed to prevent amputation on this side. Circulation in the other three extremities of these patients was adequate at rest. Death from massive retroperitoneal anaerobic infection occurred in one patient who was reoperated on for aneurysm of the femoral segment of an aortofemoral homograft bypass.

Femoropopliteal Occlusions.—Failure occurred after successful reconstructive operation in 109 of the 515 patients (21 per cent) with femoropopliteal occlusions. Although the period of function in these cases ranged from 3 weeks to 56 months, most failures occurred within the first year (Fig. 5). The incidence of recurrent difficulty varied significantly with the extent of the lesion, the type of procedure, and the material employed as a vascular replacement in the operation (Tables III and IV). The best long-term results were obtained with endarterectomy, limited to short, discrete, well-localized lesions; failure occurred in only 3 cases (15 per cent). Despite the fact that the bypass graft was employed in the most advanced and extensive lesions, late difficulty occurred in only 92 of the 479 cases (20 per cent). The poorest results were obtained in patients who had excision and arterial replacement; failure occurred in all except 2 of these. The influence of the graft material on the long-term results is demonstrated by the fact that failure occurred in 52 per cent of the patients with homografts, 32 per cent with the braided nylon Edwards-Tapp tube, and 11 per cent with the flexible, knitted, Dacron tube. Although there has been greater opportunity to observe the long-term functional results of homografts and nylon tubes than Dacron tubes, the length of follow-up does not appear to be the most important factor leading to differences in late failure. For example, analysis of a comparable series of patients followed from 18 to 30 months reveals a significant difference in the percentage of successful long-term results (Fig. 6).

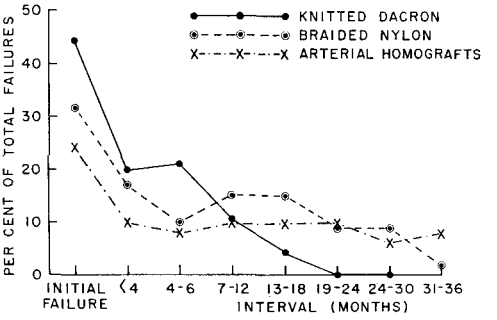


Fig. 5.—Rate of graft failure after operation for femoropopliteal occlusion, comparing functional results of Dacron tubes, nylon tubes, and homografts.

At the end of 18 to 24 months 75 per cent of the Dacron tubes were still functioning in contrast to 64 per cent of the nylon tubes and 60 per cent of the homografts. Similarly, study of the differences in the rate of failure indicates that all failures with Dacron tubes occurred during the first 18 months and that good function was obtained in all cases during the next 12 months (Fig. 5). On the contrary, a small but significant percentage of the nylon grafts and homografts continued to fail in subsequent months, the rate being greater with homografts, despite the fact that most late failures occurred during the

first 24 months. The nature and incidence of the complications leading to failure, as will be described later, were also related to the type of operation performed and the material employed as the graft.

Of the 109 patients with recurrent difficulty after successful reconstructive operation for femoropopliteal occlusions, 20 did not return for examination. Failure of operation was confirmed by examination in 89 patients with arteriography in 83 (76 per cent) which included 2 patients who had endarterectomy, 4 who had excision and graft replacement with homograft, and 77 who had the bypass graft procedure (homograft in 17, braided nylon tube in 26, and Dacron tube in 34 cases). Arteriograms made before operation and after failure were available in 57 cases, and serial arteriograms made before operation and before and after failure were available in the remaining 26 cases. These studies were analyzed and correlated with other available information such as that obtained from reoperation. Reoperation, however, although informative in some cases, did not reveal as much information as desired regarding recurrent occlusions. For example, operation in patients with recurrent obstruction frequently consisted of bypass graft extending both proximal and distal to the previous operation without exposing the latter. This approach often did not permit operative confirmation of the cause of recurrent obstruction.

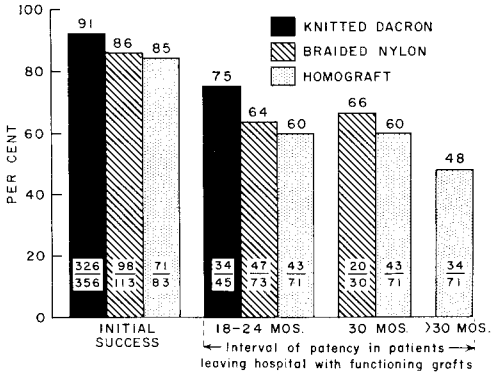
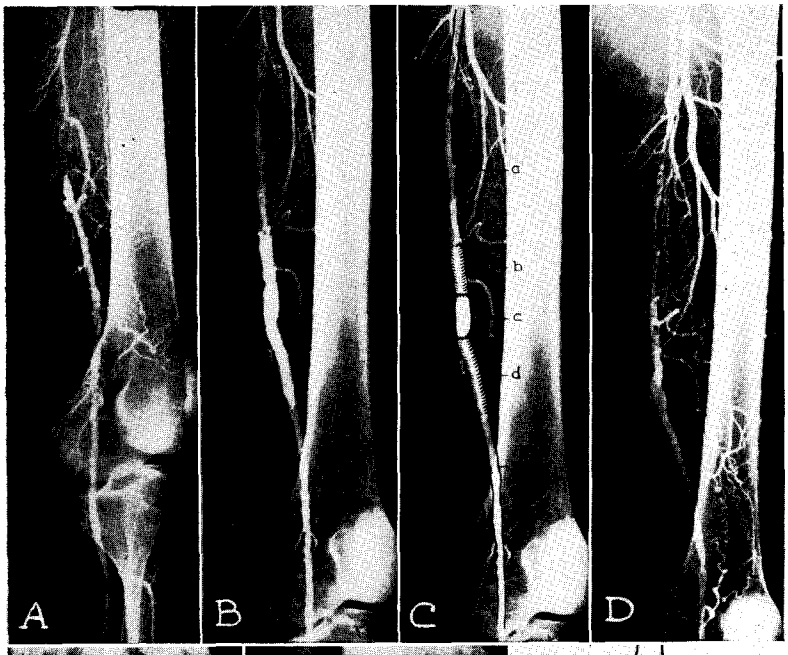


Fig. 6.—Immediate and long-term results according to vascular replacement after operation for femoropopliteal occlusion.

The complication leading to failure was reasonably obvious in most instances (Table VII). Recurrent difficulty was due to certain technical surgical factors in 47 patients (57 per cent), and the underlying disease in 36 (43 per cent). Occlusive lesions causing recurrent obstruction were present in the vessels proximal to the region of operation in 11 patients and distal to the previous operative site in 25 patients. This complication was responsible for failure in all 6 of the patients in whom excision and homograft replacement or endarterectomy had been performed (Fig. 7). These procedures were employed early in our experience when the significance of minimal-to-moderate proximal and distal disease was not appreciated. In the remaining 30 patients in whom this complication occurred after the bypass procedure, the proximal and distal disease was overlooked because of poor quality of the arteriograms leading to improper performance of anastomosis in relationship to the disease. For example,

Fig. 7.



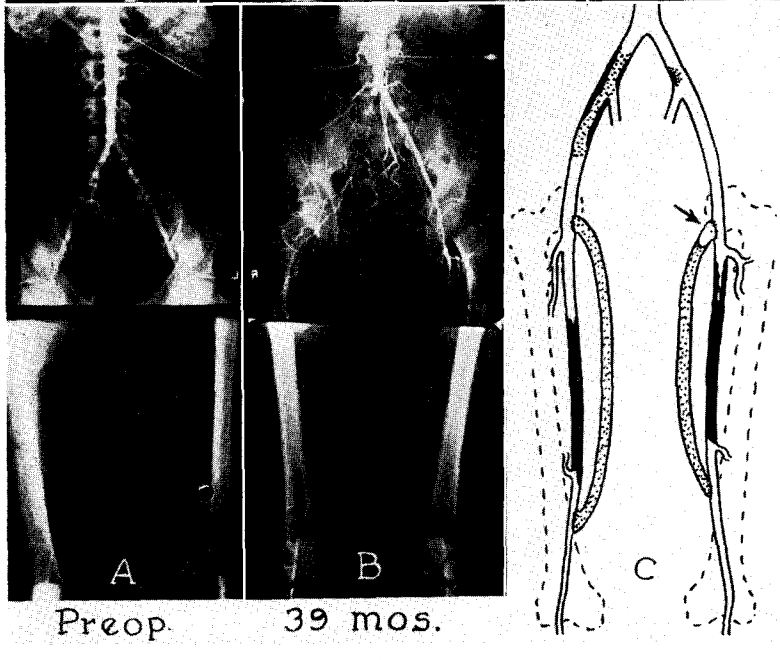


Fig. 8.

Fig. 7.—Arteriograms made before operation (*A*) showing complete obstruction of superficial femoral artery, and immediately after (*B* and *C*), showing excision and homograft replacement (*c*) with endarterectomy (*b* and *d*) leaving partial obstruction (*a* and *e*), becoming complete (*D*) above the region of operation 54 months later.

Fig. 8.—*A*, poor quality aortogram and femoral arteriogram vaguely showing partial occlusion of both iliac arteries overlooked before performing bilateral femoropopliteal bypass. Aortogram made 39 months after operation (*B*) and diagram (*C*) showing proximal complete occlusion of right iliac artery, partial occlusion of left iliac artery, and distal occlusion of both grafts except for small segment at anastomosis on left (*arrow*). Popliteal arteries remain unchanged.

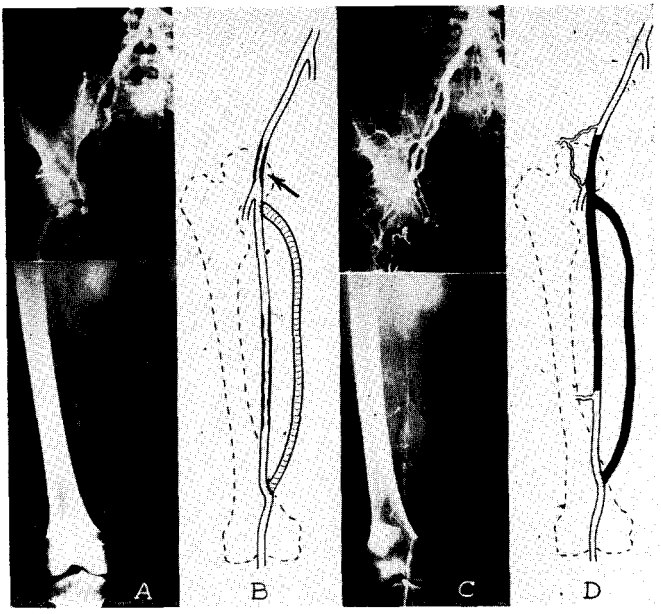


Fig. 9.—Overlooked proximal partial occlusion of right common femoral artery causing late occlusion of femoral bypass graft. *A*, Poor quality preoperative aortogram and femoral arteriogram vaguely showing (*arrow*) partial occlusion of proximal segment of common femoral artery and partial occlusion of right superficial femoral artery. *B*, Diagram of operation showing bypass graft employed distal to occlusion (*arrow*). *C*, Aortogram and femoral arteriogram 4 months after operation showing complete proximal occlusion of common femoral artery and distal bypass graft. Distal popliteal artery remains unchanged. *D*, Diagram of failure showing occlusions in black.

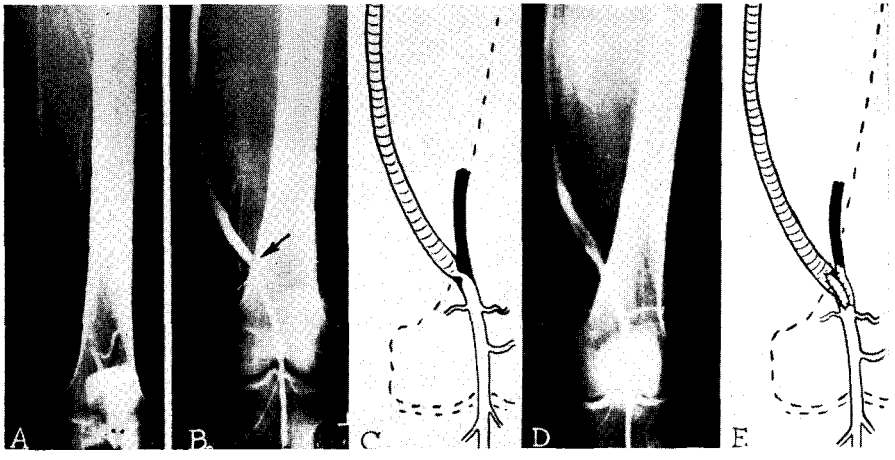


Fig. 10.—Operative failure resulting from performance of distal anastomosis in region of disease proximal to normal patent distal segment. *A*, Preoperative arteriogram showing complete occlusion of distal segment of superficial femoral artery with partial occlusion above prominent collateral vessel. *B*, Arteriogram made 10 months after operation because of persistent symptoms showing partial occlusion at anastomotic site from persistent occlusive disease not bypassed at operation. *C*, Diagram showing outflow from graft partially obstructed by persistent disease (*in black*). *D*, Arteriogram 10 days after removal of obstruction by endarterectomy showing patent channels. *E*, Diagram of operation showing patch graft closure of longitudinal incision employed for endarterectomy.

femoral grafts were inserted distal to the iliac occlusion in some cases, and in others the distal anastomosis was performed above occlusions located in the popliteal artery (Figs. 8-10).

TABLE VII. CAUSES OF LATE FAILURE ACCORDING TO REPLACEMENT IN 83 CASES OF FEMOROPOPLITEAL OCCLUSION

REPLACEMENT	ANEURYSM OF GRAFT	FALSE ANEURYSM	NARROWED ANASTOMOSIS	DISTAL DISEASE	PROXIMAL DISEASE	CAUSES RELATED TO GRAFT	TOTAL
Dacron	0	2	2	11	6	13	34
Braided nylon (Edwards-Tapp)	0	6	4	6	2	8	26
Homograft	4	0	0	7	2	8	21
Endarterectomy	0	0	0	1	1	0	2
Total	4	8	6	25	11	29	83

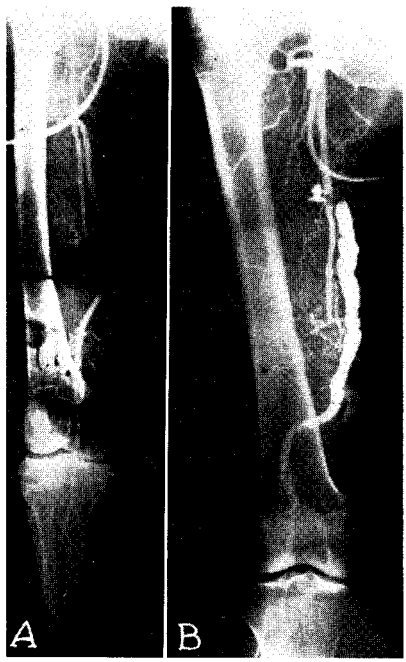


Fig. 11.—Arteriograms made 1 month after operation showing arterial homograft bypass with minimal narrowing in the proximal anastomosis (*A*), and 56 months after operation showing degeneration of homograft and progression of obstruction at proximal anastomosis (*B*).

The remaining complications resulted from causes related to the graft in most instances and varied with the type of replacement employed in the performance of the bypass procedure. Graft failure occurred in 12 homografts, fusiform aneurysms occurred in 4, and other complications related to the graft, such as dilatation, stricture, and deterioration occurred in 8 cases (Fig. 11). The cause of graft failure in 18 patients who had braided nylon tubes was false aneurysm in 6, narrowed anastomosis in 4, and technical difficulties, such as twisting and kinking, in 8. Graft failure from this cause occurred in 17 patients

who had Dacron tubes, false aneurysm in 2, and mechanisms related to insertion of the tube in 15 cases (Figs. 12-15).

Most failures due to causes relating to the graft, such as kinking, twisting, deterioration, and mechanical difficulties concerned with insertion, were observed at reoperation or were visualized by serial arteriograms. In some, however, this cause was determined from studies that did not include actual visualization of the graft itself. For example, in some patients whose arteriograms of the functioning graft were not available, this was considered the cause of failure because, as in the proved cases, the arterial channels after failure appeared unchanged arteriographically from those preceding operation. This seemed even more reasonable since short segments of the occluded graft could be visualized after failure in the region of each anastomosis, so that progression of disease and anastomotic difficulties could be excluded as causes of failure (Fig. 15). In some patients without serial arteriograms, the distal, previously patent arterial segment was partially or completely obliterated after failure. Reoperation, consisting of transection of the Dacron bypass near its origin and insertion, removal of fresh thrombus from the patient's vessels through the proximal and distal graft segments, and insertion of a second bypass graft sutured proximally and distally to the short segments of the old graft, restored circulation and an arteriographic pattern similar to that before the original operation in 9 cases (Fig. 14). Failure in these cases was also considered to be due to abnormality of the graft. The other cases with similar arteriographic observations not explored in this manner were recorded as failures due to extension of distal disease, although in reality the graft may have been at fault.

Treatment in the 109 patients with recurrent difficulty after femoropopliteal reconstructive operation depended upon a number of factors including whether or not the patient returned for treatment, the extent of symptoms particularly when different from the preoperative ones, and the extent of the occlusive process. The indication for the original operation in these cases was intermittent claudication or mild-to-moderate rest pain in 92 (84.5 per cent), and severe rest pain associated with cutaneous lesions threatening amputation in 17 patients (15.5 per cent). Although these symptoms were relieved in all patients by the initial operation, somewhat different symptoms developed in every patient after recurrent obstruction. For example, recurrent cutaneous lesions developed in only 7 of the 17 patients (41 per cent) who had had this symptom before operation and in only one of the 92 with intermittent claudication. Claudication and rest pain were worse in 8 of the 92 patients (8 per cent) with this symptom before operation. Peripheral circulation and the symptoms of arterial insufficiency were better after an initial period of graft function than before operation in some cases as indicated by this finding in 12 of the 89 patients (13 per cent) who returned for examination and treatment.

Amputation was performed elsewhere in 3 of the 20 patients who did not return for examination, and in the remainder peripheral circulation allegedly remained unchanged. Most patients, with severe recurrent symptoms or whose symptoms became worse, returned as was expected. Of the 89 patients examined, 83 were studied for the possibilities of a second reconstructive operation.

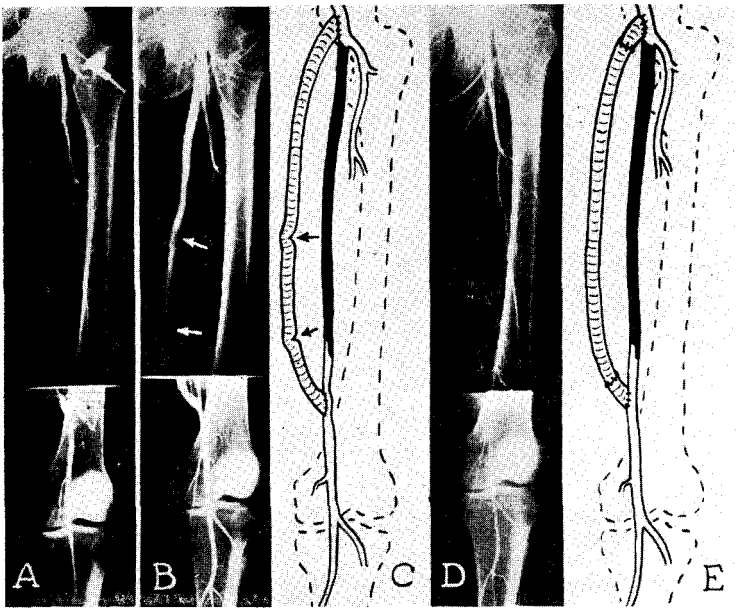


Fig. 12.—Case demonstrating failure from kinking of graft. *A*, Preoperative arteriogram showing extensive complete occlusion of superficial femoral artery. *B*, Arteriogram made 3 months after operation showing kinks (*arrows*) in Dacron graft. *C*, Diagram showing kinks (*arrows*) and occlusion (*in black*). *D*, Arteriogram made 18 months after operation showing occlusion of graft and progression of occlusion into popliteal artery by thrombus. *E*, Diagram showing method of operation in which old graft is transected near previous anastomoses and new graft is inserted after removal of proximal and distal thrombus through short segments of old graft left attached to arteries for new anastomoses.

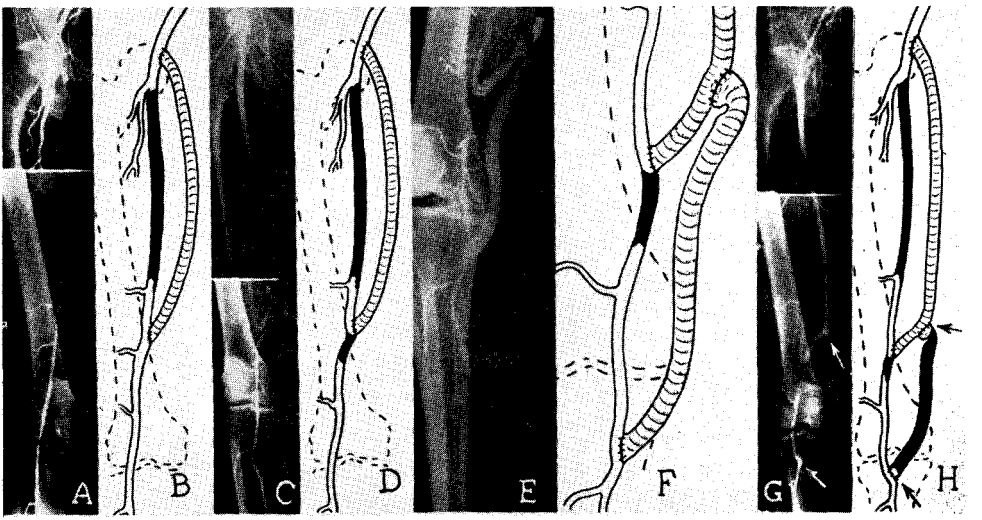


Fig. 13.—Case demonstrating failure from kinking of graft. *A*, Preoperative arteriogram showing complete occlusion of superficial femoral artery. *B*, Diagram of femoropopliteal Dacron graft bypassing occlusion (*in black*). *C*, Arteriogram made 8 months after operation showing occlusion of popliteal artery just distal to anastomosis. *D*, Diagram showing bypass graft and occlusion (*in black*). *E*, Arteriogram made at operation showing kink just distal to proximal anastomosis of new graft to old graft. *F*, Diagram showing bypass graft with kink and obstruction (*in black*). *G*, Arteriogram made 3 months after second operation showing occlusion of second graft and persistent patency of arterial segments. Region of previous anastomosis (*arrows*) is obviously not obstructed. *H*, Diagram showing obstructed graft and site of anastomosis (*arrows*).

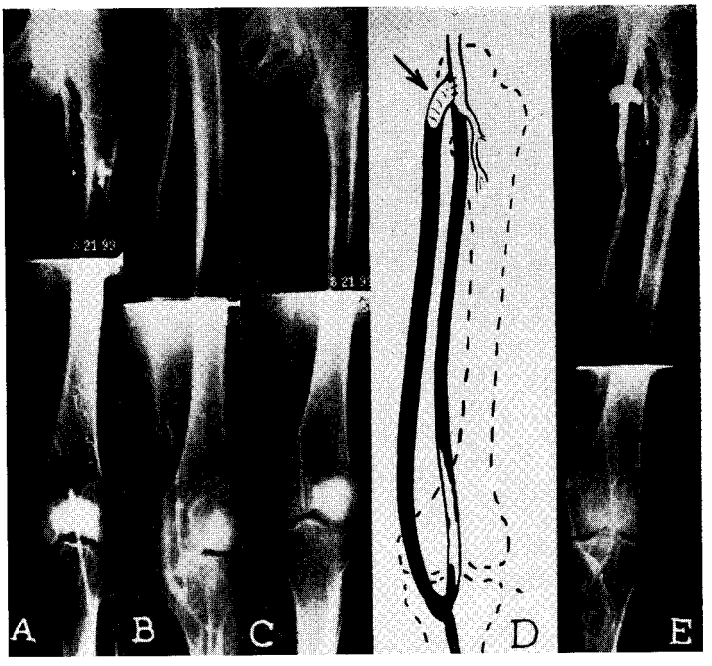


Fig. 14 —Arteriograms and diagram showing occlusion of superficial femoral artery (*A*), functioning Dacron bypass graft 10 days after operation (*B*), occlusion of graft and distal popliteal artery 3 months after operation (*C*), occlusion (*D*) (*in black*), and new functioning bypass graft inserted after thrombectomy through distal end of old tube preserved for site of new anastomosis (*E*).

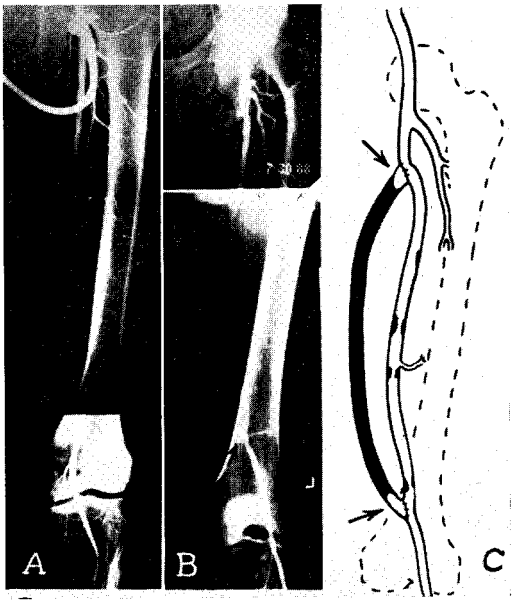


Fig. 15.—*A*, Arteriogram made before operation showing partial occlusion of superficial femoral artery. *B*, Arteriogram made after graft occlusion 17 months after bypass graft operation showing sites of patent anastomoses and unchanged arterial segments indicating occlusion resulting from factors related to tube. *C*, Diagram showing occluded tube and patent anastomoses.

These studies indicated that the lesion remained segmental and amenable to reconstructive operation in 72 cases (86 per cent). In the remaining 11 cases the disease had progressed to involve the major part of the previously patent distal segment. Peripheral circulation at rest was good in 5 of the latter patients; consequently operation was not advised. Sympathectomy was performed in 2 of the patients with diffuse involvement, and, because of the advanced nature of the lesion and the severe associated ischemic changes, amputation was performed in 4 patients. Of the 72 patients with segmental lesions, 8 declined operation because their symptoms were better than before the original procedure; the remaining 65 had a second operation (Table VIII).

TABLE VIII. RESULTS OF REOPERATION IN 64 PATIENTS WITH FEMOROPOPLITEAL RECURRENT DIFFICULTY

	REGRAFT		
		SUCCESSFUL	
COMPLICATION	CASES	CASES	PER CENT
False aneurysm	6	5	83
Anastomotic narrowing	6	6	100
Graft difficulties	28	28	100
Distal disease	12	8	66
Proximal disease	8	7	87
Aneurysm of homograft	4	4	100
Total	64	58	91

The type of secondary reconstructive operation employed depended upon the complication that produced failure of the original procedure. Aneurysms of the homografts and false aneurysms associated with use of synthetic materials were treated by removal of the involved graft and replacement with a new graft. Recurrent obstruction was treated by end-to-side bypass graft extending usually from the proximal aorta, common iliac artery, or common femoral artery to the distal popliteal artery bypassing both the diseased segment and region of previous operation. The popliteal artery was explored in 10 recent patients who were seen soon after graft occlusion despite the fact that arteriograms showed the recurrent occlusive process extending beyond the region of previous operation frequently involving the popliteal artery (Fig. 14). This extension of the occlusive process was found to be due to thrombi. It was possible to remove the thrombus in 9 patients, and peripheral pulsatile blood flow was restored by insertion of a new graft. This indicates that reoperability is not necessarily predictable on the basis of arteriograms and demonstrates the limitations of this method of study in the cause of late failure. Operation consisted first of exposing the graft and popliteal artery in the region of the distal anastomosis. The occluded graft was then transected 2 cm. proximal to the anastomosis and the distal clot was removed from the distal segment of graft. The thrombi removed in this manner were frequently casts of the entire distal popliteal artery. A vigorous backflow of blood was obtained in 9 patients, indicating distal patency. The femoral artery and upper end of the previous graft were then exposed. The graft was transected about 2 cm. distal to its origin and the thrombus was removed from the small segment of graft still attached to the artery. The old

graft was adherent to the tissues in the tunnel and could not be removed; consequently, a new graft was inserted through a new tunnel made by blunt dissection. The two ends of the new graft were sutured to the ends of the short segments of the previous graft which were still attached in the region of anastomosis. Postoperative arteriograms showed good function of the grafts and restoration of patency of the distal segments of the arteries equal to that demonstrated before the first operation (Fig. 14). The distal thrombus could not be removed in one patient because of the organization that had occurred during the 5 days between graft failure and reoperation. This case demonstrated the importance of the time factor in reoperation of patients in whom distal occlusion has become extensive because of progression of the thrombus.

Endarterectomy with patch graft was performed on one patient who had recurrent partial obstruction resulting from progression of disease overlooked at the time of the original operation in the region of the distal anastomosis (Fig. 10). The distal end of the graft and the popliteal artery were exposed through the old incision. A longitudinal incision was made in the distal end of the graft and continued into the popliteal artery for approximately 3 cm. With the occluding lesion thus exposed, endarterectomy was carefully performed under direct vision by entering the proper cleavage plane and removing the diseased intima. The opening in the graft and popliteal artery was closed with a patch graft to prevent narrowing and recurrent obstruction. The edges of the graft and arterial incision were sutured circumferentially to the edges of an oval-shaped patch made from knitted Dacron fabric. The circumference of the vascular channel in this region was increased by a distance equal to the width of the patch.

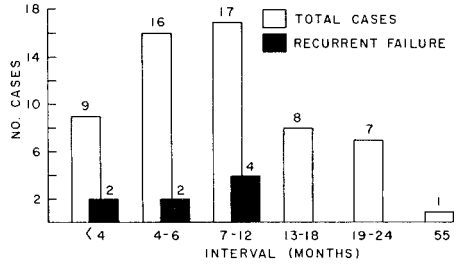


Fig. 16.—Duration of function in 58 successful cases of femoropopliteal regraft.

The results of reoperation have been entirely satisfactory. A normal pulsatile blood flow was restored in 58 of the 64 patients reoperated on (Table VIII). Death occurred from myocardial infarction in one patient and circulation was not restored in 5 patients because of the extensive nature of the occlusive process, in 4 because of atherosclerosis, and in one because of organized thrombus. Amputation was required in one of these. The peripheral circulation and symptoms of arterial insufficiency remained essentially unchanged from those before the original operation in the remaining patients in whom circulation was not restored. These patients have been followed since the second operation for periods up to 56 months, and success has been maintained in 50, including the first patient submitted to reoperation (Figs. 16-17). A third operation

has been performed successfully in 5 of the 8 patients who had late failure of the second operation; consequently, 55 of these patients (94 per cent) continue to have normal peripheral circulation.

DISCUSSION

The results of this study emphasize the usefulness of reconstructive operation in the treatment of patients with atherosclerotic occlusive disease of the lower extremities. Obstructing lesions of the distal aorta and iliac arteries are practically always segmental with a patent distal arterial bed; consequently, lesions at this level are always amenable to operation. By use of one of a variety of procedures depending upon the nature and extent of the lesion, distal circulation can be successfully improved in 96 per cent of the cases. Long-term follow-up, more than 6 years in some instances, indicates that these good results persist indefinitely in most patients; recurrent difficulties have developed in only 6.2 per cent of our cases. Particularly noteworthy is the fact that circulation was successfully restored by reoperation in 33 of the 38 patients who had recurrent difficulties after the first operation. Thus, improvement in circulation has been maintained to date, or until the patient died, in 96 per cent of our cases.

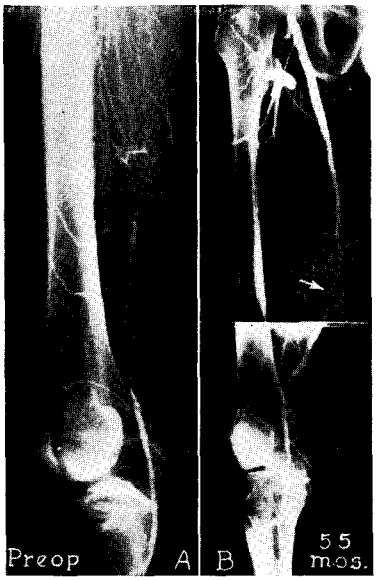


Fig. 17.—Illustrations of first patient reoperated on. *A*, Arteriogram made after recurrent occlusion showing obstruction of femoral artery. *B*, Recent arteriogram made 55 months after second operation employing arterial homograft. Irregularity of graft (*arrow*) was thought caused by deformity produced by suturing several segments of varying sizes to form long graft, although aneurysm cannot be excluded.

Atherosclerotic occlusive lesions of the femoral and popliteal arteries, although frequently extensive, are segmental with a sizable patent channel proximal and distal to the lesion in more than 60 per cent of the cases. By use of endarterectomy for discrete lesions limited to a short segment of artery or the bypass graft using a flexible knitted Dacron tube for more extensive lesions, a distal pulsatile blood flow can be restored immediately in 90 per cent and

maintained in 75 per cent of the cases for the duration of the follow-up extending more than 2 years in many instances. This immediate restoration of circulation results in relief of symptoms in all patients and, particularly, prevents amputation in patients with ischemic cutaneous lesions. These objectives of therapy unfortunately cannot be obtained with any other method at present, and despite the fact that subsequent difficulties develop in a number of patients with femoropopliteal occlusion, conservation of collateral channels by employing the bypass procedure has prevented progression of symptoms in most patients. In fact, in a considerable number of patients a significant degree of improvement occurs after a temporary period of graft function. This feature of temporary graft function assumes great importance in patients with indolent cutaneous lesions precipitated by infection and trauma. A brief period of supplemented arterial blood flow is frequently sufficient to produce healing which persists after graft failure. Moreover, in most patients with recurrent difficulty the lesion remains segmental and amenable to reoperation. By performance of a second operation, good peripheral circulation can be restored in most instances.

The late failure problem has been distorted by the results obtained from earlier procedures and graft materials that have subsequently proved of limited value. Conclusions based upon these observations alone would be discouraging; however, with increasing surgical experience and better understanding of the disease, both the immediate and long-term functional results have continued to improve. Review of our own experience indicates that most late failures were due to technical surgical factors. Technical mishaps, use of graft materials of limited function and application, and disregard for certain manifestations of the occlusive process caused most complications that resulted in failure. Progression or recurrence of the underlying disease was rarely the primary cause of failure. This analysis of the problem, suggesting that most failures are preventable, offers the opportunity to improve the results of reconstructive operation by improvements in surgical technique, better graft replacements, improved methods of arterial visualization, and more thorough understanding of the disease.[4]

Finally, responsibility must be assumed for the many patients in whom reconstructive operation has already been employed. As previously indicated, a variety of complications do occur which occasionally may pose a threat to both the patient's life or extremities. Fortunately, these complications are rare, but a defeatist attitude may be easily assumed in cases involving such complications. However, as this study has shown, by aggressive action a successful result may be obtained in most instances. For example, aortoduodenal fistula must be suspected in every patient with upper gastrointestinal bleeding after abdominal aortic graft operation. Immediate operation is indicated because the diagnosis cannot be established and proper treatment instituted by any other method. Likewise, immediate reoperation is indicated in patients whose symptoms of arterial insufficiency are worse after graft closure, particularly if loss of the extremity is threatened. As previously indicated this situation usually results from obliteration of the distal central channels by a thrombus which has extended from obstruction in the graft or more proximal disease. This thrombus can be removed when operation is performed soon after graft closure, and a normal pulsatile blood flow restored by insertion of a new graft.

SUMMARY

Although a high degree of success may be obtained initially in patients having reconstructive operations for atherosclerotic occlusive lesions of the aorta and the iliac, femoral, and popliteal arteries, continued observation reveals a significant number of recurrent difficulties. A study was made of this problem in the treatment of 1,225 patients in order to evaluate this form of therapy, to discover possible causative factors that might be eliminated or minimized by improvements in technique, and to evaluate the methods of treatment of patients with recurrent occlusion.

By means of a variety of procedures adapted to the nature and extent of the occlusive process, peripheral pulsatile circulation was initially restored in 96 per cent of the 638 patients treated surgically for lesions of the aorta and iliac arteries. Some of these patients were followed for periods longer than 6 years. Thirty-eight patients (6.2 per cent) had recurrent difficulties resulting from aneurysmal dilatation of the graft, false aneurysm, aortoduodenal fistula, or recurrent obstruction. These complications are preventable with present knowledge of treatment of lesions in this location. Particularly noteworthy is the fact that circulation was successfully restored in 33 of the 38 patients who had a second reconstructive operation.

Peripheral pulsatile circulation was restored in 88 per cent of the 587 patients on whom reconstructive operations were performed for occlusion of the femoral and popliteal arteries. The best results (91 per cent) were obtained with the bypass procedure and a flexible, knitted Dacron graft. This procedure was used in more than 50 per cent of the cases. The poorest results were obtained in the small number of patients treated early in our experience by endarterectomy or excision and graft replacement. Late failure occurred in 109 patients (21 per cent) and varied with the type of procedure and graft replacement employed. Failure occurred in most patients who had excision and graft replacement. Long-term functional results of the flexible, knitted Dacron tube inserted as a bypass graft were superior to those in which braided nylon or homografts were used. Most of these failures resulted from preventable complications, and circulation was restored in 58 of 64 of these patients (91 per cent) by reoperation. This study indicates that the immediate and long-term functional results of operation may be significantly improved by increasing surgical experience, better understanding of the underlying disease, improved methods of arterial visualization, and better graft material. Also aggressive treatment of late failures is usually successful.

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Discussion

DR. SHEPHERD (Boston, Mass.).—I would like to stress the importance of long-term follow-up in tracing the progress of these patients postoperatively.

We have operated on a group of 40 patients with aortic occlusion over a period of greater than 15 months. The 40 patients are divided into two groups: 14 had a thromboendarterectomy and 26 were treated by insertion of grafts, usually bypass gafts. Excluding the 9 deaths or closures in the hospital (one of which was a patient lost to follow-up), there were 31 patients available for follow-up. The long-term patency rate is 64.5 per cent in the whole series, not as high a percentage as has been reported by many other groups.

The thromboendarterectomies were performed chiefly in the high localized occlusions. The grafts were used in the more extensive occlusions, and we feel that this accounts for the difference in results between the two types of surgery.

One of the major factors which Dr. Key mentioned, and we also feel is very important in the incidence of closure, is the appearance of lower occlusion in the femoral arteries below the aortoiliac level. In this series, we have treated 11 patients by long grafting; these grafts are carried from the aorta or iliac artery down to the low femoral or popliteal artery (this is a bypass procedure). Nine of these patients had a successful result, and they are all symptomless.

Twelve other patients who had evidence of femoral disease were not treated in this way, and the results in this part of the series were not so good in that a number of them had residual symptoms and the incidence of closure was much greater. The 9 closures in this group all had some evidence of femoral disease.

In patients with occlusions with a high aortoiliac level, and also a low femoral popliteal level, operative treatment alone is not likely to produce good results, and early closure of the reconstruction is likely. In these cases, it is possible that the procedure of choice is a long bypass graft carried from the aorta or common iliac past both occlusions down to the popliteal artery.

DR. EDWARD J. WYLIE (San Francisco, Calif.).—We share Dr. Crawford's interest in determining the cause of failure following arterial reconstruction. For this purpose we recently reviewed our series of 230 patients who had undergone thromboendarterectomy for what were thought to be purely segmental occlusive lesions at the aorta-common iliac level. Over a 9-year period there were 7 instances in which reocclusion occurred in the endarterectomized segment. All these lesions were re-explored. Recurrence of frank atherosclerosis in the endarterectomized vessel was observed in only 2 cases. In the other 5, atheromatous occlusion had developed distal to the lower level of endarterectomy. Subsequent proximal propagation of intraluminal thrombosis resulted in occlusion of the previously endarterectomized segment.

(Slide.) This preoperative aortogram shows what appears at first glance to be an incompletely occlusive lesion in the proximal one-third of the right common iliac artery. Endarterectomy was confined to the involved segment, leaving behind the slightly thickened intima which can be seen at the common iliac bifurcation. Two years later, intimal thickening at the lower level had progressed to complete occlusion and required reoperation.

(Slide.) This aortogram shows segmental occlusion of the right common iliac artery. Operation was limited to this segment. We were reluctant to extend the operation to the opposite side, since only a minimal lesion could be palpated in the proximal left external iliac artery. The lesion was a narrow tongue of atheroma on the posterior wall, a common lesion rarely visible by aortography. Within 4 years, the tongue had progressed to the extent that it caused complete left external iliac occlusion.

As a result of these and similar experiences in 3 other cases, we have concluded that long-term arterial patency following aortoiliac thromboendarterectomy can be assured only by removal of all zones of thickened intima adjacent to occlusive lesions.

(Slides.) These two slides indicate the rate of growth of an atheromatous deposit in one patient during a 2-year period. This man originally underwent successful popliteal thromboendarterectomy for the 3 cm. lesion shown on the aortogram. An asymptomatic lesion in the left common iliac artery, with an approximately 20 per cent narrowing of the arterial lumen, was shown on the same study. Two years later, aortography showed that the iliac constriction had progressed to almost complete occlusion, resulting in claudication of the left thigh and weakening of the left common femoral pulse.

Dr. Crawford's approach to the investigation of late failures, including repeated arteriography and re-exploration, is particularly vital if we are to remedy the causes of failure.

DR. ROBERT R. LINTON (Brookline, Mass.).—I have been interested in the subject of arterial reconstructive surgery by the utilization of various types of grafts for a number of years. I was somewhat surprised to find that from the report fom Toronto, we only heard of one autogenous vein graft that was used, despite the work done by Dr. Gordon Murray many years ago on the success of various types of autogenous venous grafts.

There still seems to be a need for the ideal graft, and I would like to complement what Dr. Lord has already said, namely, that the saphenous vein is the best graft that we now have available for occlusive disease in the lower extremity. I would like to document this for you with a few colored slides and arteriograms in a man in his early 50's with a block in his superficial femoral artery. In 1956, I implanted an arterial homograft from the common femoral artery down to his popliteal artery. (Slide) Aneurysmal dilatation of the homograft developed, as you see in this slide, which was taken 2 years after the grafting procedure.

Because I did not have sufficient homograft at that time, I had to use a small piece of saphenous vein autograft to make the bypass graft sufficiently long. This was implanted at the distal end. The slide shows a distal anastomosis between the homograft here and the saphenous vein autograft, and also the popliteal artery where it was implanted. You will notice that the saphenous vein looks about the same size as the day I put it in.

(Slide.) One year later, the proximal part of the homograft had become aneurysmal in this short period of time. This is one of the great difficulties and faults I have found with homografts and the reason I hesitate to use them any more for femoral grafts. If you will remember what this homograft looked like one year before and compare it with this picture, you will see what tremendous degenerative changes have taken place in the last 12 months of the third year in which the graft had been functioning.

(Slide.) When I took out the aneurysmal, dilated homograft at the second operation, I inserted another piece of saphenous vein autograft and here is the original saphenous vein which had been functioning for 3 years, and the one which I had put in one year previously. Neither has dilated—both look exactly the same size as the day they were implanted.

(Slide.) This shows the aneurysmal dilatation of the homograft, and I would like to again demonstrate the utilization of autogenous tissue in this case, not only by the use of autogenous venous grafts, but also by means of endarterectomy popularized by Drs. Cannon and Wylie. It was possible, after endarterectomizing the common femoral and

superficial femoral arteries, to anastomose the proximal end of the saphenous vein grafts, which I had already implanted and were in place, to the distal end of the endarterectomized superficial femoral artery with complete restoration of circulation of the extremity, and leaving the patient now with entirely autogenous tissue. In every instance, if you can use autogenous tissue either by utilization of saphenous autograft or endarterectomizing the femoral artery, these are the preferable procedures, and my first choice is the former.

DR. JOSEPH M. JANES (Rochester, Minn.).—I am not from Toronto, but I would like to come to the defense of Toronto. In the early 1930's, Dr. Gordon Murray, a senior member of this organization, was inserting autogenous vein grafts for popliteal aneurysms.

DR. OSCAR CREECH, JR. (New Orleans, La.).—We spend a great deal of time talking about runoff area, and perhaps it is the runin which is of equal if not more importance. I think Jack Wylie has also emphasized this in the past. We have had a number of patients with complete occlusion of the femoropopliteal system in whom it was impossible to establish a good runoff area in the sense that the anterior and posterior tibials were open, but, by opening the superficial femoral and popliteal arteries down to the bifurcation, we were able to maintain a good flow to that area, through collaterals coming off laterally from the superficial femoral.

In patients who have had femoral bypass grafts that became occluded, we have used thromboendarterectomies in several instances and have obtained a successful restoration of blood flow.

(Slide.) This is an example of a bypass graft in a patient who had superficial femoral obstruction which subsequently became occluded. This patient had inflow occlusion as well as outflow occlusion. We performed a thromboendarterectomy both above and below, and, by doing this and leaving the graft in place, we were able to restore pedal pulses and relieve symptoms. This has been done in several instances and seems to be a satisfactory approach to the problem of graft failures.

DR. JERE W. LORD, JR. (New York, N. Y.).—I would like to describe one patient with obstruction from a different cause. He was an individual of 35 who presented with gangrene of the toes of one foot and markedly diminished circulation for 4 months. An aortogram (slide) made in January, 1957, shows stenosis at the origin of each of the common iliac arteries with thrombotic narrowing of the distal aorta. He was treated by thromboendarterectomy as Dr. Wylie outlined and taught me. His pulses were excellent, his gangrene demarcated, and his toes were saved. Oscillometrics went from near 0 to around 10 in each leg.

He did very well for 6 months. Then, rather abruptly he developed claudication again. In October, 1957, some 8 months after the first operation and after 6 months with good results, he was explored. It was anticipated that either disease had been overlooked, which I did not think likely, or more probably that he had new arteriosclerotic occlusive disease. The aortogram done before the second operation suggested arteriosclerotic narrowing in the terminal aorta at the beginning of the common iliac. At operation we found what I believe to be a fibrotic periarterial squeezing of the common iliac arteries and of the terminal aorta. Fear of causing a dangerous hemorrhage from the inferior vena cava and iliac veins made me decide to divide the aorta above and the common iliacs beyond the point of narrowing. We opened the obstruction and found a perfectly smooth intima without any sign of thrombosis or any sign of the intimal placquing. I believe, therefore, that he had periarterial fibrosis, although following his first operation he had a perfectly benign clinical course. This time we inserted end-to-end a Dacron prosthesis, one of Drs. Julian and Deterling's material, a product of the Ethicon Company, with end-to-end aorta above and end-to-end common iliacs below.

He did well for 10 months, had excellent pulsations on limited walking distance, and then began to show signs of shutting off.

Because this was a sturdy young man and because of his remarkable faith in his professional care in spite of two surgical onslaughts, last December, 6 months ago, he

underwent a third operation, and this time I had the opportunity to use one of Dr. De Bakey's crimped Dacron prostheses, and he had again an end-to-end above, end-to-end below on the right of the common iliac, and end-to-side to the external iliac on the left.

He was in the office on Friday, now has excellent pulsations, excellent oscillometrics, but he has still not gone the critical year, and I am hoping that Dr. De Bakey's material will be more satisfactory than that previously used.

DR. KEY (closing).—Dr. Linton will be glad to know that we are using some autogenous vein grafts now, and I was very glad that Dr. Janes paid a tribute to Dr. Murray of Toronoto. I now understand that he has some patients that he has followed for as long as 18 to 20 years after the use of vein grafts.

The paper was not in any way an attempt to compare the newer materials to the older. We do not use nylon now and we use very few homografts. The idea was, as I said, to give us a yardstick for future comparison of such materials.

In the long-term results with these grafts, we are going to have inevitable failure either of the graft or the patient's heart. Dr. Spaulding in a review of patients from the onset of claudication noted in the age group 55 to 65, there was a 4 per cent mortality in 10 years. It would seem, therefore, perhaps in some of these patients, we are not only restoring the life of the limb, but we appear to be increasing the longevity of the patient.